Second Annual Summary

CAN NNS06AA05G
NASA VOLCANIC CLOUD DATA FOR AVIATION HAZARDS

Volcanic eruptions can eject large clouds of ash and sulfur dioxide (SO_2), posing a substantial risk to aircraft and passengers. The University of Maryland, Baltimore County / Joint Center for Earth Systems Technology and its partners, NOAA, USGS, and the FAA, continued development this year of an operational system for inclusion of SO_2 marker data from NASA research satellites into volcanic hazard Decision Support Systems. This year, several improvements were made to the operational system, including major noise improvements in OMI SO_2 data, resolution of background offset correction failure in OMI near real-time (NRT) data, and completion of the error analysis of the OMI Linear Fit (LF) algorithm.

The system was used to track several volcanic eruptions during the past year, including Tungurahua (Ecuador), Kilauea (Hawaii), Anatahan (Mariana Islands), and Etna (Sicily). The OMI-AIRS system detected SO_2 emissions following a small volcanic eruption near Manda Hararo, Afar, Ethiopia in August 2007; this event was featured on NASA's Earth Observatory (http://earthobservatory.nasa.gov/NaturalHazards/natural_hazards_v2.php3?img_id=14473). Two significant volcanic events were also monitored. Based on an AIRS SO_2 alert received on September 30, 2007, the staff of the Washington Volcanic Ash Advisory Centers (VAAC) notified the Toulouse VAAC of volcanic activity in the Red Sea area near Yemen. Toulouse VAAC personnel had not realized an eruption had occurred at Jabal al-Tair, and as a result of the notification sent out an advisory to the aviation community shortly thereafter. The eruption was tracked in near real-time with OMI data for nearly 2 weeks (Figure 1). A second significant volcanic event occurred on January 1, 2008, when the Llaima volcano in Chile erupted for about 12 hours, producing an 1100 km long plume that drifted over Argentina. The plume continued drifting eastward until conversion to sulfate four days later over the Atlantic Ocean (Figure 2). This event was detected by both OMI and AIRS.

Major accomplishments:

- OMI SO_2 products are now used by USGS and volcano observatories to assess volcanic activity.
- Daily production images are available at http://so2.umbc.edu/omi.
- Near real-time images are available at http://satepsanone.nesdis.noaa.gov/pub/OMI/OMISO2/index.html. This website displays near real-time SO_2 detects for a global composite of OMI orbits as well as for the latest orbital SO_2 data contained within a set of fixed geographic regions. New capabilities include
    - option to view 3 prior day images over a fixed region,
    - inclusion of a toggle to alternately view SO_2 and Effective Reflectivity data,
    - addition of location and names of volcanoes embedded in each image
    - addition of three volcanic region images
    - addition of an index map showing location of all image subsets on both websites.

Publications

Carn, S.A., N.A. Krotkov, K. Yang, R.M. Hoff, A.J. Prata, A.J. Krueger, S.C. Loughlin, and P.F. Levelt (2007). Extended observations of volcanic SO_2 and sulfate aerosol in the stratosphere, *Atmos. Chem. Phys. Discuss.*, 7, 2857-2871. (http://www.copernicus.org/EGU/acp/acpd/7/2857/acpd-7-2857.htm)

Carn, S.A., A.J. Krueger, N.A. Krotkov, S. Arellano, and K. Yang (2008). Daily monitoring of Ecuadorian volcanic degassing from space, *J. Volcanol. Geotherm. Res*., doi:10.1016/j.jvolgeores.2008.01.029 (in press).

Carn, S.A., A.J. Krueger, N.A. Krotkov, K. Yang, and K. Evans (2008). Tracking volcanic sulfur dioxide clouds for aviation hazard mitigation, *Natural Hazards*, doi:10.1007/s11069-008-9228-4 (in press).

Yang, K., N. Krotkov, A. Krueger, S. Carn, P. Bhartia, and P. Levelt, Retrieval of Large Volcanic SO_2 Columns from the Aura Ozone Monitoring Instrument (OMI): Comparison and Limitations, accepted by the *Journal of Geophysical Research* Special Issue on AURA validation.

Conference/Workshop Presentations

Carn, S., N. Krotkov, K. Yang, A. Krueger, F. Prata, R. Hoff, Advances in the detection and tracking of volcanic clouds from space,WMO Fourth International Workshop on Volcanic Ash, Rotorua, New Zealand, March 26-30, 2007.

Carn, S., N. Krotkov, A. Krueger, R. Hoff, K. Yang, and F. Prata, New Insights into Volcanic Degassing from OMI and the A-Train, Envisat Symposium, Montreux, April 24-27, 2007.

Carn, S., A. Krueger, S. Arellano, M. Segovia, L. Troncoso, N. Krotkov and K. Yang, Daily monitoring of Ecuadorian volcanic degassing from space, AGU Joint Assembly 2007, May 22-25, 2007.

Carn, S., N. Krotkov, A. Krueger, and K. Yang, A survey of volcanic degassing in the Americas since 2004, AGU Joint Assembly 2007, May 22-25, 2007.

Carn, S.A., N.A. Krotkov, M.R. Schoeberl, P. Wennberg, J.E. Dibb, B.E. Anderson, G. Diskin, G. Sachse, S.A. Vay, K. Yang, A.J. Krueger, S. Arellano, Direct sampling of tropospheric volcanic plumes in Ecuador and Colombia during TC4, Aura Science Team Meeting, Pasadena, CA, October 1-5, 2007.

Carn, S.A., A.J. Krueger, N.A. Krotkov, K. Yang, K. Evans, Measuring volcanic emissions with the Ozone Monitoring Instrument (OMI) (invited paper), Cities on Volcanoes 5 meeting, Shimabara, Japan, November 19-23, 2007.

Krotkov, N., A. Krueger, K. Yang, S. Carn, PK Bhartia, and P. Levelt, SO_2 Data from the Ozone Monitoring Instrument (OMI), Envisat Symposium, Montreux, April 24-27, 2007.

Krueger, A., N. Krotkov, and S. Carn, The 1982 El Chichon Eruption: The Birth of Volcanic Sulfur Dioxide Monitoring From Space, AGU Joint Assembly 2007, May 22-25, 2007.

Krotkov, N., A. Krueger, K. Yang, S. Carn, P.K. Bhartia, K. Evans, OMI SO_2 product status and overlook, OMI Science Team meeting, University of Maryland, Baltimore County, Baltimore, Maryland, June 5-8, 2007.

Krotkov, N.A., What have we learned about global SO_2 sources with OMI data? (poster), Aura Science Team Meeting, Pasadena, CA, October 1-5, 2007.

Krueger, A., S. Carn, K. Evans, N. Krotkov, K. Yang, P. Levelt, G. Serafino, G. Vicente, M. Guffanti, D. Schneider, G. Hufford, C. Kessinger, NASA research satellite data for volcanic aviation hazards, NOAA/NESDIS/SAB Seminar series, October 23, 2007.

Krueger, A., S. Carn, K. Evans, N. Krotkov, K. Yang, P. Levelt, G. Serafino, G. Vicente, M. Guffanti, D. Schneider, G. Hufford, C. Kessinger, Sulfur dioxide monitoring for volcanic aviation hazards, Workshop on Global Support to Aviation Control, Toulouse, France, November 26-27, 2007.

Swanson, G. and G. Serafino, Use of Volcanic Sulfur Dioxide Satellite Observations for Operational Monitoring of Volcanic Activity, Workshop on Global Support to Aviation Control, Toulouse, France, November 26-27, 2007.

Vicente, G., The NOAA Near Real-time OMI-SO_2 Cloud Visualization and Product Distribution System, AGU Fall Meeting, San Francisco, CA, December 10-14, 2007.

Supporting Figures: OMI sulfur dioxide data

(Jebel al-Tair eruption)

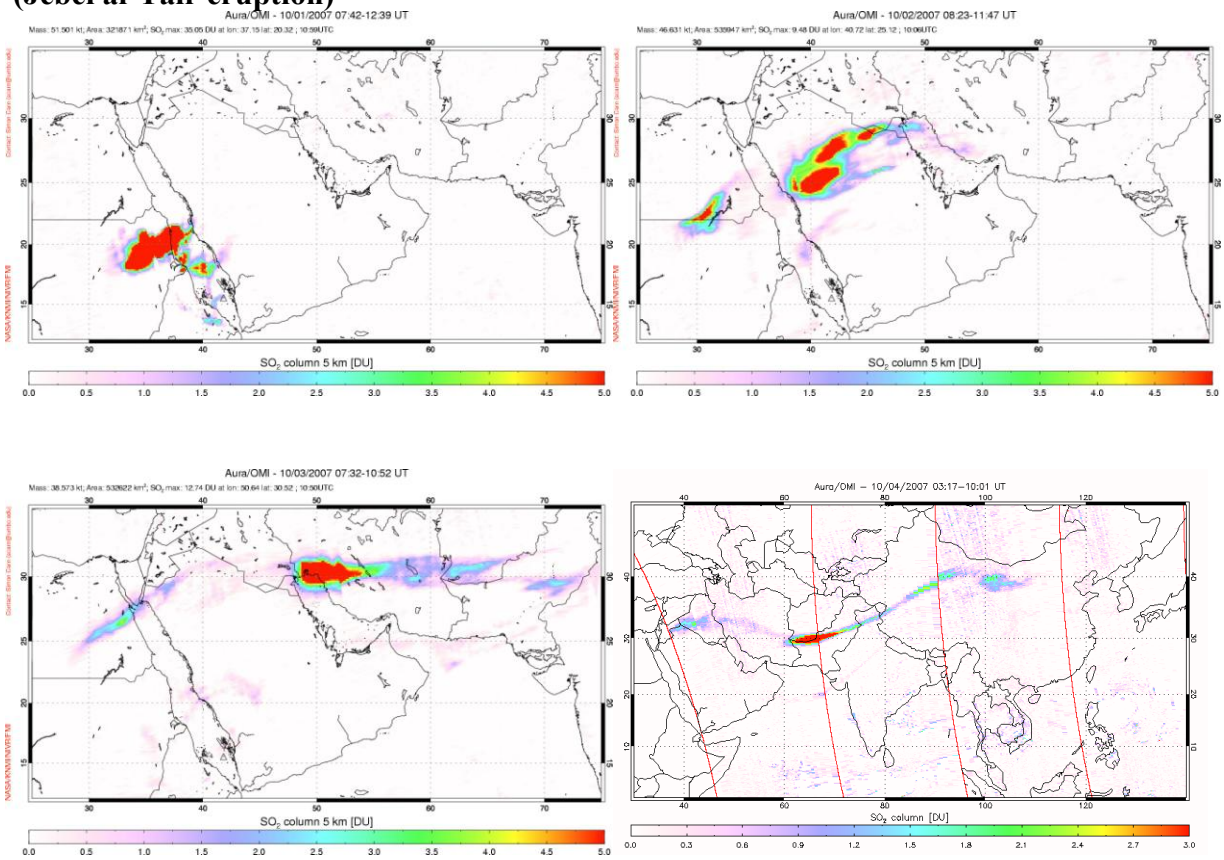

Figure 1 Jebel al Tair volcano in the Red Sea, thought to be extinct, erupted on September 30, 2007 and produced a sulfur dioxide cloud that was stretched by subtropical jet stream winds across southern Asia. The plume altitude, near the tropical tropopause at 17 km, measured in Calipso data, was above typical aircraft flight altitudes. This effusive eruption from a basaltic volcano produced only a small amount of ash that fell out near the island.

Lliama eruption

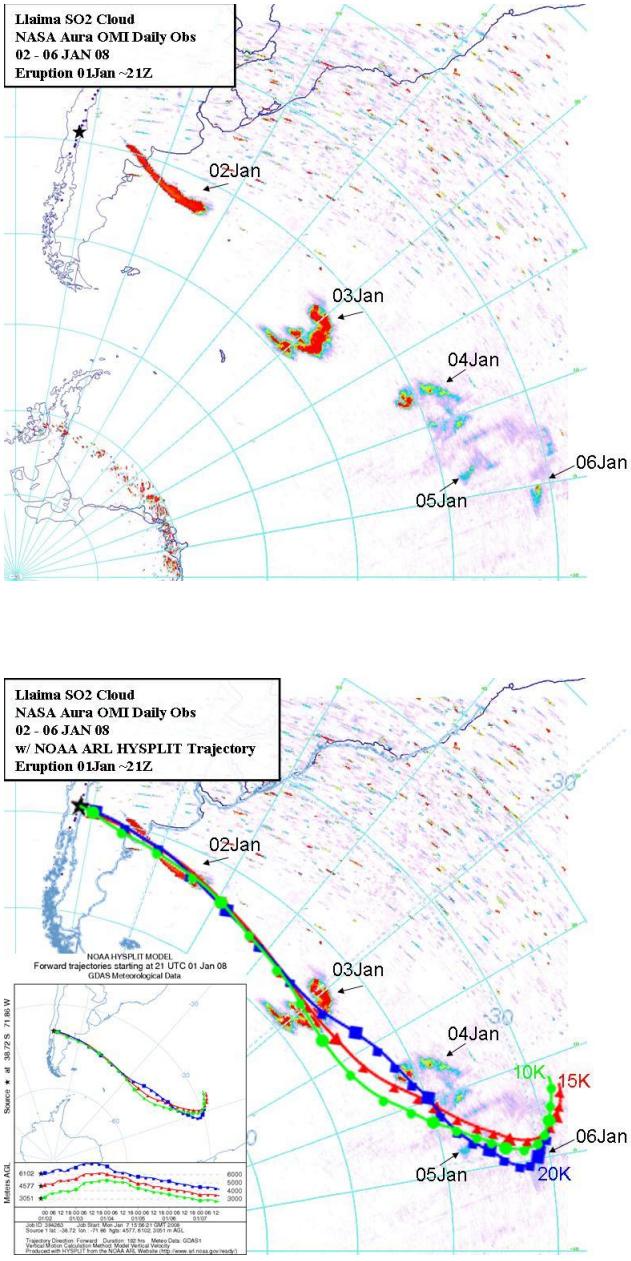

Figure 2. Llaima erupted on the evening of Jan 1. According to the Buenos Aires VAAC, the resulting ash cloud reached an altitude of 12.5 km (41,000 ft). On Jan 4, the volcanic SO_2 cloud drifted over Tristan da Cunha in the South Atlantic.